

The Role of DOE's National Laboratories in International Biomass Research, Development, and Deployment

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DOE International Biofuels Collaboration



- Goals
 - Accelerate progress toward biofuels R&D goals through leveraging of resources and expertise
 - Reduce global greenhouse gas emissions and reliance on oil
 - Promote business partnerships and global economic development

- Major Activities
 - EU
 - IEA
 - Brazil
 - Global Sustainability Studies
 - China
 - India
 - Israel
 - APEC

DOE's Biomass Program Portfolio



Removing barriers to large-scale production of cellulosic biofuels

Collaborative R&D

- Feedstocks: integration of feedstocks with conversion processes
- Conversion Technologies: biochemical and thermochemical
- Integrated Biorefineries: systems integration, demonstrations, infrastructure development

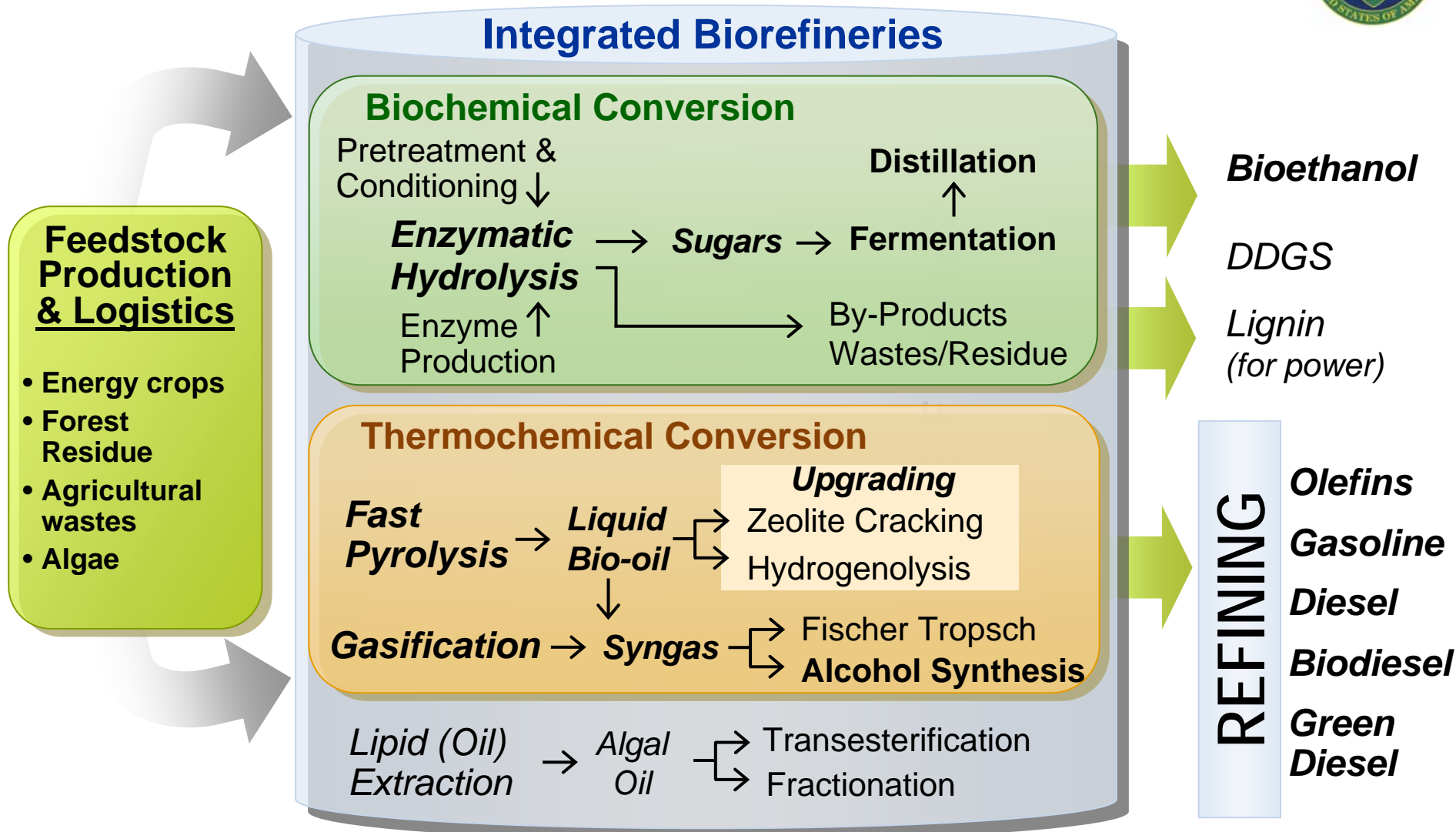
Integrated Biorefineries

- Systems Integration: feedstocks, conversion, biopower, infrastructure
- Demonstrations: pilot scale and commercial scale for diverse feedstocks



DOE efforts are paving the way for a strong, domestic bioenergy industry—
with commercial success possible in the next six years.

Cellulosic Biomass for Biofuels and Commodity Biochemicals



DOE's Program Includes Research, Development, and Demonstration Activities on Biofuels

The DOE National Laboratories Assist DOE in Meeting Biofuels Goals



- The Role of National Labs in Biofuels
 - National Labs conduct focused R&D to reduce barriers
 - Biochemical and thermochemical technologies
 - Technoeconomic, life-cycle, and other analyses
 - Labs partner with industry and universities
 - National Labs partner with industry on biorefinery demonstrations
- Current DOE-OBP/National Laboratory Partners
 - National Renewable Energy Lab (NREL)
 - Pacific Northwest National Laboratory (PNNL)
 - Idaho National Laboratory (INL)
 - Oak Ridge National Laboratory (ORNL)
 - Argonne National Laboratory (ANL)
 - Sandia National Laboratory (SNL)



National Laboratories and International Biofuels Projects



- Numerous mechanisms for collaboration:
 - Labs lead technical tasks in support of multilateral programs – IEA, GBEP, APEC, IPCC, etc.
 - Partnering with technical institutes in other countries in conducting joint work in support of DOE and USG bilateral agreements and priorities
 - Can also develop CRADAs and WFO agreements with international research partners that go beyond the scope of DOE or USG supported work
 - Promoting researcher to researcher collaborations
- Many types of collaborations and specific projects are underway
- Projects vary by region, country, and agreement



- Joint Roadmap on S&T Cooperation Meeting held In October in Brussels with DOE and European Commission (DG-RTD)
 - Agreed joint actions for cooperation
 - Algae/Biofuel
 - Advanced biofuels
 - Pyrolysis
 - Biorefinery
 - Sustainability issues
 - Mechanisms
 - Cross-participation in workshops
 - Cost-shared analyses
 - Exchanges of scientists
 - International participation in major solicitations





Thermochemical Technology Objectives

- Analysis of biomass pyrolysis to produce bio-crude oil for converting to hydrocarbon fuels (green gasoline/diesel) or heat/power
 - Assessment of the feedstocks suitable for pyrolysis in the two regions
 - Technoeconomic analysis of fuels and for heat/power applications
 - Market analyses including identification of opportunities, comparison of distribution concepts, and others
 - Project is starting in 2009
- Partners
 - PNNL, NREL, VTT Laboratory (Espoo)

Sweden



Bilateral Implementing Agreement -- 2007 -- technologies, products, services, and resource base for renewable energy

Biochemical Technology Objectives

- ❑ Comparative evaluation of techno-economic process models.
- ❑ Approaches to improve feedstock reactivity and pre-treatment efficacy.
- ❑ Analysis for commercial biomass hydrolysis.
- ❑ Comparative benchmarking of microbe lines for fermentation performance, selectivity, etc.
- ❑ Genetic and microarray analysis of transcriptional control.
- ❑ Fungal strain engineering, compiling a library of *Aspergillus niger* strains to screen changes in protein secretion and organic acid production.

Thermochemical Technology Objectives

- ❑ Comparative analysis of gasification kinetics and catalyst performance.
- ❑ Gas-phase membrane separation - feed enrichment and product recovery.

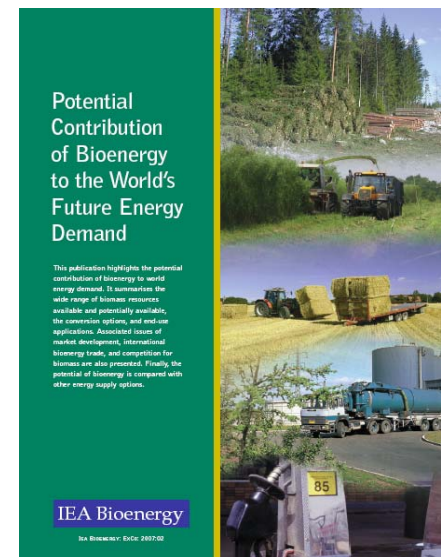
Partners:

- Energy Technology Center, Pitea, Lund University, Uppsala University
- NREL, PNNL

International Energy Agency's Bioenergy Agreement



- Membership includes 22 governments from Europe, North and South America, Pacific Rim countries, and Africa
 - Annual budget is approx \$1.7 million
- IEA/BA has 13 collaborative Tasks in the following areas:
 - Biomass production
 - Biomass conversion
 - Sustainability
 - Biorefineries and commercialization
- Activities include:
 - Information sharing, staff/student exchanges
 - Reports and analyses of specific issues
- DOE Laboratory participation:
 - Leadership of Tasks on biomass gasification (NREL) and pyrolysis (PNNL)
 - Participation in many Task activities by several Labs
 - Networking and information exchange



www.ieabioenergy.com

Multilateral Energy Cooperation of U.S. and Brazil governments through the US – Brazil MOU To Advance Cooperation on Biofuels



◦ **Bilateral (DOE Lead)**

- Advancement of R&D of next generation biofuels technology
 - Multiple bilateral government visits -- 2007-2008
 - Bilateral Visits to Set Up Research Collaboration -- 2007-2008
 - Identify Specific Collaborations – 2008 - present
 - Work on Biofuels Sustainability – 2007- present

◦ **Third Countries (DOS Lead)**

- Joint work to bring the benefits of biofuels to select third countries through feasibility studies and technical assistance aiming at country production/use of biofuels. Haiti, Dominican Republic, El Salvador, and St. Kitts and Nevis (2007-8); Guatemala, Honduras, Jamaica, Guinea-Bissau, and Senegal (2008-ongoing)

◦ **Global (DOC/NIST and DOS Lead)**

- Expansion of the biofuels marketplace through cooperation on the establishment of uniform codes and standards. White Paper: http://www.nist.gov/public_affairs/biofuels_report.pdf
- International Biofuels Forum to facilitate multilateral activities (Brazil, US, India, China, the European Commission, and South Africa)

Signed on 3/9/2007 by U.S. Secretary of State and Brazilian Foreign Relations Minister

Brazil Biofuels Collaboration

MOU: Advance the R&D of Next Generation Biofuels Technologies



- Joint areas for R&D identified by the delegations
 - U.S. visit of 14 RD&D and commercial Brazilian organizations in 2008;
 - Brazil visit to 4 DOE/USDA labs, 1 each company and univ in U.S. in 2007
- Key areas are:
 - Advanced Biofuels Production – bio and thermal (DOE and USDA)
 - Systems Integration and Modeling (DOE) includes technoeconomic, LCA
 - Biomass Production (USDA)
- Intl. Memorandum of Understanding signed on October 2008 between Petrobras' Research Center (CENPES) and NREL



Brazil Biofuels Collaboration: Impact of Ethanol Expansion on GHG and Air Toxics



Brazil (UNICAMP)

- Sugarcane to ethanol
 - Baseline 2005
 - 2020 with CHP and bagasse to ethanol and CHP
 - Paper published by I. Macedo and J. Seabra 2008 (Biomass and Bioenergy)
- Brazilian LCA baseline data inserted in GREET (2008)
- Joint Post-Doctoral Assignment Brazil/US
 - Seabra at NREL: technoeconomic evaluation of bagasse-to-ethanol (thermal & bioconversion)

U.S. (NREL, ANL)

- Corn to ethanol
 - Baseline 2007
 - 2020 with improved conversion technologies and CHP and stover to ethanol
- Reviewed recent GHG studies
 - 2005 meta analysis LCA results found about -18% from gasoline
 - New data show higher reductions in new mills. About - 40% (increase corn plant productivity and conversion process improvements). With biomass providing CHP projected – 50% to - 60%. Results do not consider indirect Land Use Change (iLUC).
 - Using GBEP GHG Task Force Methodology in meta-analysis



- U.S.-Brazil Effort is Advancing Biofuels LCA and Modeling of Direct and Indirect Land Use Change
 - Collaborative activities will identify gaps in scientific knowledge; and promote science-based global sustainability frameworks
- Multilateral - DOE and Laboratories (ANL, NREL, ORNL) providing technical support to
 - Global Bioenergy Partnership (GBEP)
 - IPCC Renewable Report – Biomass preparation
 - Roundtable on Sustainable Biofuels
 - Collecting Sustainability Data from multiple countries
 - Identifying Gaps in literature and knowledge



US-China MOU Cooperation for the Development of Biofuels

- US Department of Energy and US Department of Agriculture in US
- National Development and Reform Commission and National Energy Administration in China
- Negotiated biofuels research collaboration areas and signed December 2007
- Four joint R&D areas for DOE (multi-lab) and USDA developed with Chinese working groups

Resource Assessment

- ORNL with Chinese Energy Research Institute et al
- Exchange of information and capacity building for advanced resource assessment and sustainable biomass feedstock development for biofuels
- Training and use of software tools, GIS and satellite remote sensing techniques, supply curves, use of marginal lands, transition and cellulosic feedstocks
- Application of advanced techniques in provincial pilot studies

Sustainability Assessment and Life Cycle Analysis

- ANL, ORNL, and NREL with Chinese partners
- LCA applied to specific technology paths, emphasizing advanced feedstocks and processes
- Sustainability assessment applied to economic, environmental and social factors
- Participation in joint biomass assessment under US National Academy of Science and Chinese Academy of Sciences cooperation project

Biochemical Feedstock Conversion Joint Research

- NREL with Tsinghua University et al
- Characterization and validation of performance of new yeast strains from China for use in sweet sorghum dry and wet fermentation processes
- Application of yeast strains to fiber conversion and pentose fermentation
- Enzymatic hydrolysis of sorghum bagasse cellulosic feedstocks and characterization of surface and compositional analysis

Thermochemical Feedstock Conversion Joint Research

- PNNL with Dalian Institute of Chemical Physics et al
- Techno-economic analysis of distributed pyrolysis and gasification for mixed alcohol synthesis
- Characterization and performance verification of new Co and Rh catalysts from China
- Evaluation of distributed pyrolysis followed by gasification-proof of concept



India



- Support biofuels development and deployment activities in India through a program of collaborative technical efforts
- Energize and further develop the U.S. - India relations under the bilateral Energy Dialogue
- Pursue biofuels project opportunities that are mutually beneficial to both countries
- Technical partners include the Indian Oil Corporation (IOC) and relevant governmental agencies such as the Ministry of New and Renewable Energy (MNRE)

India



Accomplishments

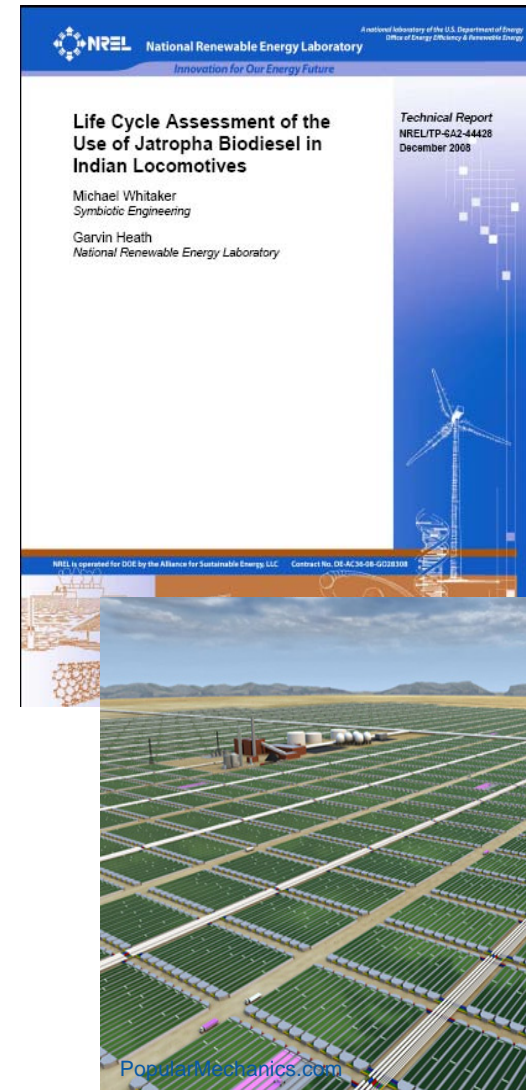
Life Cycle Assessment (LCA) of biodiesel from jatropha for use in *rail* transportation and compare it to petro-diesel

Ongoing Tasks

LCA of biodiesel from jatropha for use in *road* transportation and compare it to petro-diesel

Technical assistance in building a cellulosic ethanol pilot plant at the Indian Oil Corporation's R&D facility

Algae resource assessment – evaluate various factors such as climate, CO₂, water and land availability to identify areas in India suitable for algae production



Israel



- **Technical Scope:**

- NREL coordinating Israel-U.S. collaborative RE and EE research, development, demonstration, and deployment (RD3)
- Initial solicitations announced 2.09 - \$2m combined U.S-Israel funds, plus \$ private cost share
 - Projects with at least one organization from each country
 - BIRD – private industry leads for projects with 2-4 year commercialization time frame, up to ~\$500k/year per project
 - BSF – academic and lab partnerships for basic science research, ~50k/yr/project
 - Biofuels one of three topic areas for initial solicitation, along with vehicles and CSP
- House mark adds \$2m for EERE portion to this, which Israel MNI has committed to matching if it clears Senate

- **Partners**

- Israeli Ministry of National Infrastructure
- Binational Industrial Research & Development (BIRD) Foundation, “BIRD Energy”
- Binational Science Foundation; “BSF Energy”



- **Key Deliverables**

- Minimum 2-3 commercial biomass bilateral partnerships with awards by August 2009
- Minimum 2 basic science grants for bilateral academic research
- Government-to-government pre-competitive grants (awarded without competitive solicitations)
- 2-3 US-Israeli scientific researcher exchanges currently planned, more going forward

Israel: Seambiotic Algal Biomass Partnership



Technical Scope:

- Development and testing of cost-effective processes for producing and harvesting algal biomass using open raceway ponds
- Development and testing of novel algal oil extraction and conversion processes
- Completion of Lifecycle analyses for algal biomass production for algal biomass production for biofuel feedstock
- Assessment of scale-up feasibility for selected US and Israel regions

Partners:

- NREL: Al Darzins,
- Sandia National Labs: Grant Heffelfinger
- Seambiotic: Professor Ami Ben-Amotz (also of IOLR)
- Center of Excellence for Hazardous Materials Management – Doug Lynn,

Key Deliverables:

- Report on development and testing of cost-effective production and harvesting processes
- Report on results of novel extraction and conversion tests
- Life Cycle Assessment reflecting the systems, processes, and logistics of the target U.S. & Israeli operations
- Report on feasibility for scale-up

Asia Pacific Economic Cooperation (APEC)

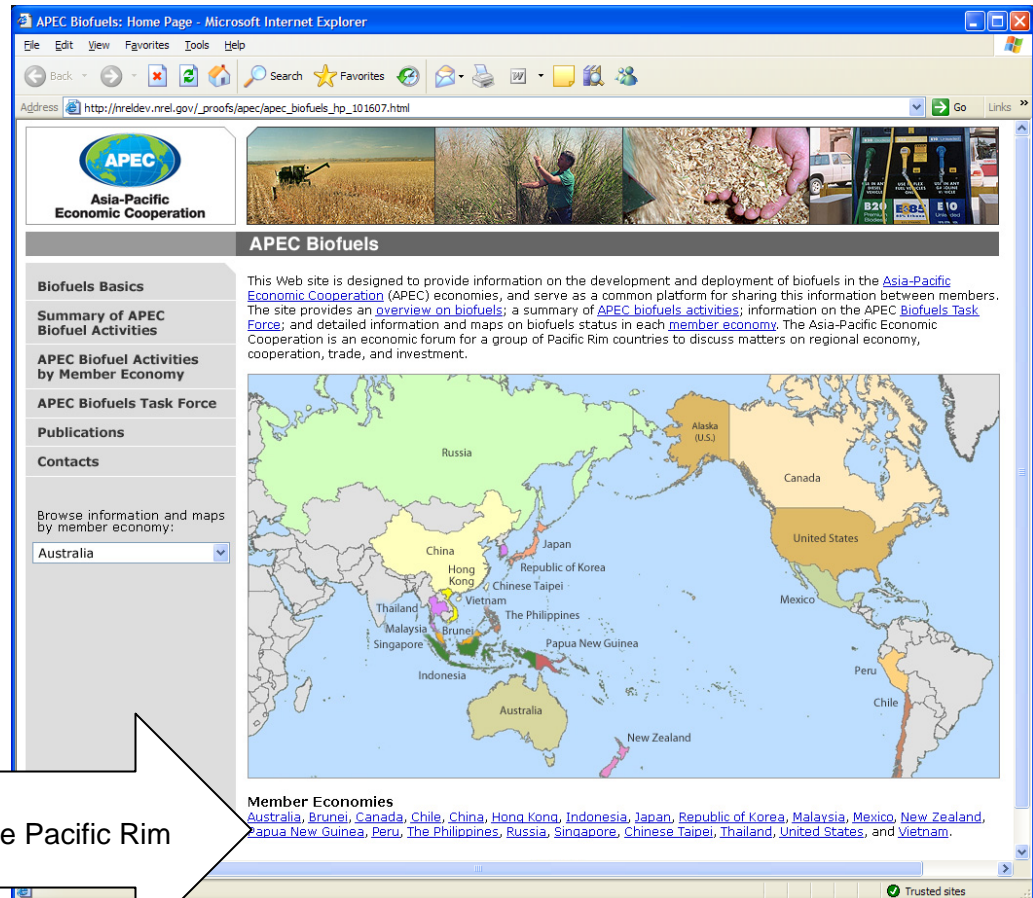


Publications:

- The Future of Liquid Biofuels for APEC Economies
- Survey of Biomass Resource Assessments and Assessment Capabilities
- Biomass Resource Assessment on Marginal Lands (ongoing)

Production
Resources
Economics
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for 21 economies along the Pacific Rim



<http://www.biofuels.apec.org>

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